stants are necessary to adapt this equation to the portions of the curve representing numbers of rainfall days per year at stations having over 100 inches, and less than 100 inches rainfall per year, respectively. Two equations of this form, which taken together are in excellent agreement with the plotted points, are shown on the diagram, and the heavy lines (2–a) and (2–b) are plotted from values calculated by these equations. While it seems probable that this type of equation represents a rational form of relation between the number of rainfall days and the amount of rainfall per annum at a given location, there is no reason to expect that the constants in the equation should be uniform over so wide a geographical range of territory as India affords.

Apparently, however, for stations in India having more than 100 inches of rain, a single formula will give approximately accurate results for all stations, and a separate formula will apply equally well to all stations having less than 100 inches of rain. Stations having over 100 inches of rain are mostly at high elevations and their high rainfall is largely due to orographic conditions. Where these conditions exist it may naturally be expected that the relation between the rainfall amount and duration will differ from that pertaining at coastal stations or in flat regions.

As illustrating the probable variation of the number of wet days at a single station from the mean for the same amount of rainfall the data were tablulated for the 61 stations having rainfall amounts between 19 and 21 inches, respectively. For rainfall between 19 and 21 inches, there are 6 cases with the number of days between 22.8 and 25, 24 cases with the number of days between 25 and 30, 25 cases with the number of days between 30 and 35, 2 cases with the number of days between 35 and 40, 4 cases with the number of days between 40 and 45; least number of days, 22.8; greatest number of days, 43; mean number of days, 30.1.

The chance is 4 to 5 that departure for a single station will not exceed one-fifth the mean number. Inspection of the complete data shows similar relations to hold for larger rainfall amounts.

Summer rainfall rate and duration in India.

Amount.		Number of stations.	Average inches per year.	Average number rain days.	Average inches day.
From—	To—				
0	10	91	6.6	13.3	0.50
10	20	158	15.8	24.2	.65
20	30	496	25.4	38.7	.66
30	40	443	34.9	46.6	.75
40	50	333	44.6	55.5	.80
50	60	207	54.9	70.1	.78
60	70	111	64.4	80.6	.80
70	80	67	75.7	92.4	.82
80	90	49	84.8	106.8	.79
90	100	60	94.5	111.9	.84
100	150	144	118.8	116.7	1.01
150	200	34	169.6	132.0	1.28
200+	.....	14	239.8	140.6	1.70

ARE WE HAVING LESS SNOWFALL?

By CLARENCE J. ROOT, Meteorologist.

[Weather Bureau Office, Springfield, Ill., Aug. 24, 1923.]

Central Illinois experienced a very light snowfall during the winter of 1922–23; in fact, there have been several successive winters with rather light amounts. This has led numerous persons to make remarks similar to this: "We do not have the big snows that we did when I was a boy, and I do not think we will ever have them again." Is it true that we do not have the big snows that we did, or is it a matter of viewpoint? No doubt the snow that reached to the shoulder of the small boy of the seventies and eighties does not seem very deep to the mature man of 1923. Then, again, many of our city men lived in the country as boys, where the wind has full sweep over the prairies and large drifts are piled up.

Although the snowfall at Springfield has been rather light during several of the more recent winters, the greatest fall of record, 43 inches, occurred as late as the winter of 1913–14. The Springfield winter totals have been averaged for periods of 10 years, beginning in 1884, with the following results: 20.3, 19.6, 21.9, and 20.3 inches. Thus it will be seen that there has been no material change in 40 years. The largest fall in December occurred in 1915, in January in 1918, in February in 1900, and that of March in 1906.

The Illinois climatological reports make mention of heavy snows in recent years. In January, 1912, there was as much as 21 inches in the southern part of the State, with individual falls of 15 inches. On February 22–23, 1914, a severe snowstorm occurred in central Illinois. The wind piled the snow into deep drifts, the snow being 5 to 15 feet deep in places. Business was almost at a standstill and railroad lines were demoralized.

January of 1918 was the severest month in the climatological history of Illinois. The low temperature and heavy snowfall, combined with strong winds, were very unusual. The average snowfall was almost double that of any previous January, and was considerably more than that of any previous month. The greatest total, 42.5 inches, occurred at Chicago, where the most unusual snowfall conditions in the history of the city occurred. The storm of the 6th was the severest since the weather station was established in 1871, but that of the 11th was still more so. The storm of the 11th was of the blizzard type and extended over the entire State, causing the most general and complete transportation paralysis in many years, if not in the history of Illinois railroads. Deep drifts formed, in many cases covering hedges and fences, and many wagon roads were completely blocked even as late as the end of the month. Trains were stalled all over the State. On many sections of main-line railroads there was no train movement for two or three days, and branch lines were blocked for a longer period, 10 days in one case.

During a single week of March, 1923, unusually heavy snow fell over Wisconsin and northern Illinois. At Freeport, Ill., the snow reached an accumulated depth of 25 inches. For Wisconsin the monthly average was the greatest of record for March.

In discussing this subject it may be of interest to know what has happened in other States. The following statement with reference to the winter of 1922–23 was made by Dr. C. F. Brooks in the *Bulletin of the American Meteorological Society:*

There was an extraordinary amount of snowfall in New England during the last winter. December had two times the normal amount. In January the snowfall in northern New England was twice and in the southern portion three times the average. This was followed by the usual amounts in February and March. At Portland the January

fall was 53 inches, and the winter's total exceeded 10 feet. All highways were absolutely impassable for automobiles from the first week in January to the last week in March.

Through the kindness of several of the station officials, the writer has secured comparative snowfall data for a number of the more Northern States. At Albany and New York the snowiest winter occurred more than 30 years ago, but there have been only six winters with more snow than fell in that of 1922–23. The records at New Haven extend back to 1873, and the data have been averaged by 10-year periods, beginning with the earliest records, with the following results: 48.8, 40.8, 42.3, 39, and 35.6 inches. A gradual falling off is indicated at New Haven, yet the heaviest of record occurred as late as the winter of 1915–16, and last winter the total was 19 inches above the normal.

Another old record is that of Boston, beginning with 1871. Our friends who believe the climate is changing might find comfort in learning that the greatest seasonal snowfall of record at Boston (96.4 inches) was in 1873–74, but the winter with the least snow (5.3 inches) was only two years later. By 10-year periods, commencing with 1873, the averages are: 44.1, 47, 44.5, 39.8, and 47.6 inches. The last is the greatest. Just as was the case at Albany and New York, the snowfall of the winter 1922–23 has been exceeded but six times. The total was 24.3 inches above the normal.

At Portland, Me., the greatest total snowfall for a winter (125.5 inches) occurred in 1886–87, but last winter, with but one-half inch less, was next in amount. The decade averages at Portland are: 74.8, 77, 72, and 75.9 inches. The heaviest snowfall of record at Northfield, Vt. (193 inches) occurred during the winter of 1887–88, but the second greatest was in a recent winter, that of 1921–22, and the fourth greatest just two years earlier. Rochester, N. Y., is an especially snowy place. The greatest fall (142 inches) was in 1900–1901; the least, in 1918–19. The averages by decades (10-year periods) at this station are: 76.1, 99.3, 71, and 78.3 inches. Buffalo had the greatest total in 1909–10 and the least 20 years earlier. In the West we find that Cheyenne's winter of least snow was back in 1885–86 and the greatest some 19 years later. The greatest total of record at Salt Lake City occurred in the winter of 1916–17, and the second, third, and fourth since then. The following figures are given by way of comparison, the dates indicating the winter of greatest snowfall: Columbus, 1909–10; Detroit, 1899–1900; Helena, 1880–81; Lincoln, 1914–15; Spokane, 1889–90.

There is evidence enough to permit persons in certain localities to really believe that the days of heavy snowfall are past, but viewing the subject in a broad way we are led to conclude that there will undoubtedly be heavy snows in the years to come just as there have been in the past, and it is probable that present records will be exceeded at many places.

THE NATIONAL ELIMINATION BALLOON RACE FROM INDIANAPOLIS, IND., JULY 4, 1923.

By L. T. SAMUELS, Meteorologist.

[Weather Bureau, Washington, D. C., August 20, 1923.]

The three contestants covering the greatest distance from the starting point in this event are chosen to represent the United States in the International Balloon Race—a sporting event in which contestants compete for a cup donated in 1906 by the late James Gordon Bennett. Although, as has been stated, this is a sporting event, there is extensive opportunity during these races for obtaining information of value to the science of meteorology. For this reason it has been customary for the Weather Bureau, in events of this sort, to contribute from its knowledge of wind conditions both on the surface and in the free air such information as may be of value to contestants.

Mr. C. G. Andrus was again the Weather Bureau observer in the race acting as aid to Mr. R. H. Upson, while the writer was assigned to Indianapolis for the purpose of giving the contestants first-hand information obtained from special pilot-balloon observations made at Indianapolis and at a number of surrounding Weather Bureau and Army aerological stations. In addition to the arrangements made for having this detailed information directly available at the starting place, the district forecaster at Chicago forwarded special advices for the balloonists.

Arrangements were also made to have telegraphed to Indianapolis on July 2, 3, and 4 the computed free-air pressures from a number of stations east of the Rocky Mountains. This made possible the drawing of charts depicting the atmospheric pressure at 1,000 and 2,000 meters above sea level.[1] This phase of Weather Bureau work is of recent development and it may be said that this was the first occasion of its practical application. Further reference to these charts will be made later.

Radio bulletins were issued on the evening of the 4th and the morning of the 5th from Chicago, Detroit, Schenectady, and Washington for the benefit of those balloons that were equipped with receiving sets. Only four of the balloonists availed themselves of this source of information, the winner being one of these.

It seems proper, first, to describe the dominant features of the controlling pressure areas a few days previous to the race. The weather over Indiana on the morning of July 1 was anticyclonic, the result of a high-pressure area centered over New England which was becoming merged with the permanent HIGH over the Atlantic and accompanied by relatively low pressure north of the Canadian border. This HIGH over New England had previously crossed the United States with a rate of movement greater than normal. On the next day the Atlantic HIGH continued in control causing moderate to fresh southwest winds above 1,000 meters. By the morning of the 3d there was evidence of a condition approaching stagnation, typical of the summer season, while thunderstorms were becoming general over the Lake region.

A distinct feature of the free-air conditions at this time and one gratefully welcomed by the balloonists was the continuation of moderate westerly winds at altitudes of 1,000 meters and higher, a result, undoubtedly, of the relatively lower temperatures over the Hudson Bay region. An interesting incident of the race indicating the steadiness with which the general wind drift continued was the sighting of four other balloons by Lieutenant Lawrence very close to his own after more than 12 hours in the air. After 23 hours he again sighted one of the

[1] Meisinger, C. Le Roy: MO. WEATHER REV. SUPP. No. 21. The preparation and significance of free-air pressure maps for the central and eastern United States.